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# A Highly Available Local Leader Election Service

Christof Fetzer, Flaviu Cristian

*Abstract*— **We define the highly available local leader election problem, a generalization of the leader election problem for partitionable systems. We propose a protocol that solves the problem efficiently and give some performance measurements of our implementation. The local leader election service has been proven useful in the design and implementation of several fail-aware services for partitionable systems.**

*Keywords*— **Local leader election, partitionable systems, timed asynchronous systems, global leader election.**

## I. Introduction

THE leader election problem [1] requires that a unique leader be elected from a given set of processes. The problem has been widely studied in the research community [2], [3], [4], [5], [6]. One reason for this wide interest is that many distributed protocols need an election protocol as a sub-protocol. For example, in an atomic broadcast protocol the processes could elect a leader that orders the broadcasts so that all correct processes deliver broadcast messages in the same order. The *highly available leader election problem* was defined in [7] as follows: (S) at any point in time there exists at most one leader, and (T) when there is no leader at time $s$, then within at most $\kappa$ time units a new leader is elected.

The highly available leader election service was first defined for synchronous systems in which all correct processes are *connected*, that is, can communicate with each other in a timely manner. Recently, the research in fault-tolerant systems has been investigating asynchronous partitionable systems [8], [9], i.e. distributed systems in which the set of processes can split in disjoint subsets due to network failures or excessive performance failures (i.e. processes or messages are not timely ; see Section III for details). Like many other authors do, we call each such subset a *partition*. For example, processes that run in different LANs can become partitioned when the bridge or the network that connects the LANs fails or is "too slow" (see Figure 4). One reason for the research in partitionable systems is that the "primary partition" approaches [10] allow only the processes in one partition to make progress. To increase the availability of services, one often wants services to make progress in all partitions.

Our recent design of a membership [11] and a clock synchronization service for partitionable systems [12] has indicated that we need a leader election service with different properties for partitionable systems than for synchron systems. The first problem that we encountered is hov specify the requirements of such a *local leader election vice*. Ideally, such a service should elect exactly one l leader in each partition. However, it is not always pc ble to elect a leader in each partition. For example, w the processes in a partition suffer excessive performa failures, one cannot enforce that there exists exactly local leader in that partition. To approach this probl we have to define in what partitions local leaders hav be elected: we introduce therefore the notion of a *st partition*. Informally, all processes in a stable partition connected to each other, i.e. any two processes in a ble partition can communicate with each other in a tin manner. The processes in a stable partition are require elect a local leader within a bounded amount of time. election service might be able to elect a local leader in *unstable partition*, i.e. a partition that is not stable, bu is not guaranteed that there will be a local leader in e unstable partition. We call a process "unstable" when part of an unstable partition.

In each stable partition, a local leader election ser has to elect exactly one local leader. In an unstable tition the service might not be able to elect exactly local leader. It can be advantageous to split an unst partition into two or more "logical partitions" with local leader each if that enables the processes in eacl these logical partitions to communicate with each othe a timely manner (see Figure 1). To explain this, note t our definition of a "stable partition" will require that processes in such a partition be connected to each ot This implies that when the connected relation in a parti is not transitive, that partition is unstable. For exam the connected relation can become non-transitive for tl processes $\{p, q, r\}$ if the network link between $p$ and $r$ f or is overloaded while the links between $p$ and $q$ and $q$ $r$ stay correct (see Figure 2).

In specific circumstances, our local leader service sp an unstable partition into two or more logical partiti with one leader in each. The service makes sure tha timely communication between any two processes in a ical partition is possible. However, sometimes this comm nication has to go via the local leader in case two proce $p$ and $r$ in a logical partition are only connected thro the local leader $q$ (see Figure 2.b). Informally, a log